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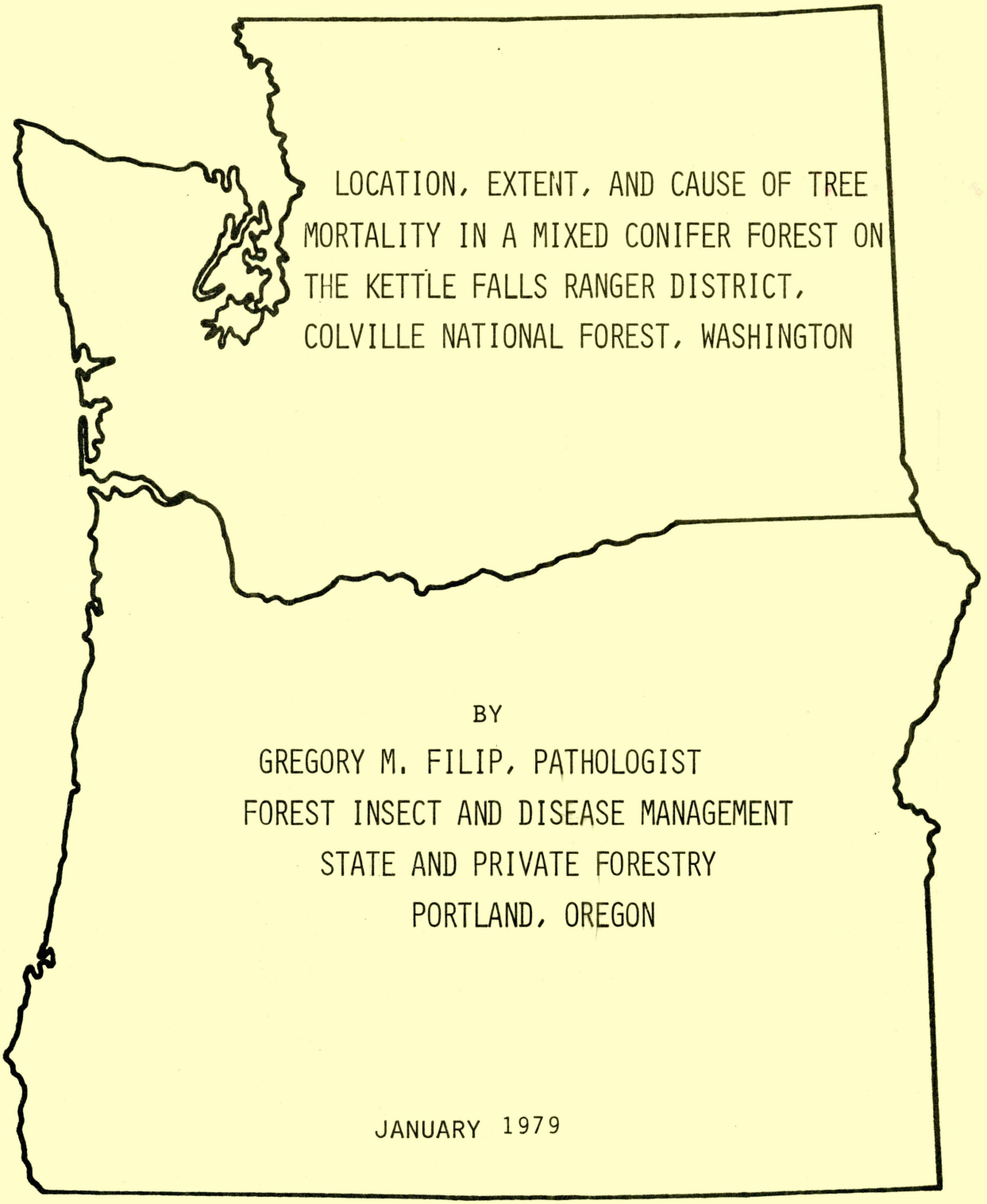

LOCATION, EXTENT, AND CAUSE OF TREE MORTALITY IN A MIXED CONIFER FOREST ON THE KETTLE FALLS RANGER DISTRICT, COLVILLE NATIONAL FOREST, WASHINGTON

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Abstract

Approximately 1,300 acres of mixed-conifer forest on the Kettle Falls Ranger District were systematically surveyed on the ground for location, extent, and cause of tree mortality. Seven percent of the stems representing 20 percent of the board-foot volume (17 percent of cubic volume) was killed over an estimated 20-year period. Major causes of mortality were identified as Armillaria root rot, bark beetles, and larch dwarf mistletoe. Recommendations aimed at minimizing future mortality are discussed.

Introduction

Root diseases, dwarf mistletoes, and bark beetles are major causes of tree mortality in the Pacific Northwest. Tree mortality caused by *Phellinus (Poria) weirii* and *Armillaria mellea*, produce mortality losses estimated to be 53 million ft.^{3} annually (3). Dwarf mistletoes cause an annual estimated mortality loss of 72 million ft.^{3} (3). Losses due to bark beetles average 77 million ft.^{3} annually (1).

Forest managers are concerned with minimizing future disease losses and need to know causes, exact locations, and extent of damage, especially damage caused by root diseases that persist through successive forest generations. Detailed stand examinations provide valuable data that can be used to formulate recommendations for treatment of damaged stands.

The Kettle Falls Ranger District, Colville National Forest, had observed numerous patches of dead and dying trees near and within the site of a proposed timber sale. They were interested in the extent, cause, and treatment of root diseases on the site. Objectives of this evaluation were to examine the site of the proposed timber sale, and 1) measure stocking (trees per acre) and volume (bd. ft. and cu. ft. per acre) of all dead trees, 2) determine causes of mortality, 3) determine exact locations of mortality centers, and 4) determine if tree species tolerant and/or resistant to root diseases are present in disease centers.

Methods

The area surveyed was near Pierre Creek (T. 40 N., R. 37 E. secs. 34, 35, and T. 39 N. R. 37 E. secs. 1, 2, and 3) on the Kettle Falls Ranger District (Figure 1). Predominant tree species were Douglas-fir (*Pseudotsuga menziesii)* and western redcedar (*Thuja plicata*). Other species present in lesser quantities included western larch (*Larix occidentalis*), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. contorta*), western hemlock (*Tsuga heterophylla*), Engelmann spruce (*Picea engelmannii*), and subalpine fir (*Abies lasiocarpa*). Many stands that were surveyed had been selectively harvested, with the largest trees being removed.

Approximately 1,300 acres were systematically ground surveyed by using 137 variable (BAF 20) and fixed diameter-circular plots (1/250 acre) spaced at 5-chain intervals (Figure 2). Plot centers were the same for both fixed and variable plots. All trees not measured in variable plots were measured if they fell within fixed plots. All trees 6 inches in height and greater within plots were measured regardless of species, merchantability, or condition (dead, live). Approximate boundaries of major mortality centers (greater than three adjacent trees) were sketched as survey lines were followed.

The following data were recorded for each plot tree: (1) species, (2) DBH, (3) crown class, (4) condition (live, dead), (5) presence of root disease or dwarf mistletoe, and (6) cause of mortality. Diameter at breast height was estimated for all trees with stems missing or disintegrated at breast height. Root diseases were detected and identified by excavating soil around root collars of suspect trees and removing small sections of bark to expose the cambium. *Armillaria mellea* was identified by presence of typical mycelial fans beneath root collar bark (Figure 3).

All data were tabulated by computer using the Stand Examination SX System Version 4, Regional Office, Portland, Oregon (2).

Results

Seven percent of the stems representing 20 percent of the board-foot volume[1/] (17 percent of cubic volume) was killed within the area

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1/ Scribner rule

surveyed. Some dead timber was harvested prior to the survey and therefore, could not be measured. Although precise measurements of year of mortality were not made, some tallied trees were estimated dead for 20-30 years based on extent of tree deterioration. Major causes of mortality were identified as Armillaria root rot, larch dwarf mistletoe, and bark beetles. Mortality caused by *Phellinus (Poria) weirii*, which causes a laminated root rot, was found in one small area (Figure 2).

Armillaria root rot killed 2 percent of the stems (Table 1) representing 2 percent of the board-foot volume (3 percent of cubic volume, Table 2). Most Armillaria-caused mortality occurred in Douglas-fir (4 percent of stems, 3 percent of volume), but several large stems of western redcedar, grand fir, and lodgepole pine were also killed. Although larch mortality due to Armillaria was relatively high (9 percent of stems), only smaller trees (5 in. DBH) were killed by root rots. Other tree species were encountered too infrequently to determine Armillaria mortality frequencies with precision. Mortality caused by Armillaria root rot was distributed evenly throughout diameter classes (Table 3). Major disease center locations are shown in Figure 2. A small percentage of living trees had root collar infections. Several others probably had infections on lateral roots, but these were not recorded.

Mortality caused by dwarf mistletoe was found only in western larch. Twenty-seven percent of the stems representing 31 percent of the board-foot volume (32 percent of cubic volume) was killed by larch dwarf mistletoe (*Arceuthobium laricis*). Most mortality occurred in larger diameter trees (Table 3) and was scattered throughout most mature stands. At least half the number of living larch had severe dwarf mistletoe infections.

Bark beetles killed less than 1 percent of the stems representing 6 percent of the board-foot volume (5 percent of cubic volume). Most mortality occurred in lodgepole pine and was caused by the mountain pine beetle (*Dendroctonus ponderosae*). Insect mortality in Douglas-fir was

found primarily in old-growth trees and was caused by the Douglas-fir bark beetle (*D. pseudotsugae)* or the flatheaded fir borer (*Melanophila drummondi)* in drought-weakened trees. Grand fir mortality was associated with fir engravers (*Scolytus ventralis)*, however several insect infested trees also had Armillaria root rot. Most bark beetle-caused mortality occurred in larger trees of all species. Locations of patches of insect killed trees are shown in Figure 2.

Most tree mortality in the area surveyed could not be assigned to a particular disease or insect. However, mortality from undetermined causes was most frequent in small diameter trees which suggests death through suppression. Mortality in larger trees was probably caused by either Armillaria root rot or bark beetles, but trees were often too deteriorated to positively identify causal agents. Some mortality was caused by windthrown trees striking and felling adjacent living trees. Although several species of hardwoods were observed in the survey, none were killed by root rot, bark beetles, or dwarf mistletoe.

Total time to conduct the survey was approximately 7 days for a crew of two.

Conclusions and Recommendations

Seven percent of the stems are dead in the survey area. Some of the mortality can be attributed to suppression, especially in smaller trees. Since many stands are overstocked in smaller size classes, mortality caused by suppression may be a benefit.

Bark Beetles

Most mortality occurs in the larger diameter classes that include the older, more decadent trees. Mortality of old-growth caused by bark beetles and larch dwarf mistletoe is common. These overmature stands should be cut and regenerated promptly to prevent further mortality and deterioration.

Timber stand improvement activities, especially thinning in overstocked stands, will increase tree vigor and minimize attack by bark beetles and to some extent, root diseases.

Dwarf Mistletoe

Impact of larch dwarf mistletoe can be reduced by removing and regenerating severely infected mature stands. Care should be taken to create mistletoe-free edges of 40-100 feet in width when clearcuts are made in larch stands. This will prevent rapid invasion of dwarf mistletoe into larch regeneration within the plantation. Infected trees overtopping susceptible regeneration should be removed before regeneration reaches 3 feet tall or 10 years old. In sapling and pole-size stands, infected trees, particularly those with infections in at least half of the crown, should be discriminated against during thinnings. In infected mixed stands, species not susceptible to larch dwarf mistletoe such as Douglas-fir, ponderosa pine, western redcedar, or grand fir should be favored.

Root Disease

In several instances, mortality caused by Armillaria root rot occurred in weakened or suppressed scattered trees. However, several adjacent trees within a 5-10 acre area were killed by Armillaria (Figure 4), especially between roads 001 and 150 (Figure 2). On these sites, it is recommended that measures be adopted to reduce infection and mortality in both existing and replacement stands. Conventional harvesting of infected trees will not prevent fungus spread to other trees and may even increase spread to and mortality in remaining trees by increasing infection potential.

One method of reducing infection in replacement stands is to plant or favor tree species that are resistant to lethal infection. Examination of mixed Douglas-fir/larch/ponderosa pine stands within and adjacent to the survey area that contain large root disease centers show that

Douglas-fir appears to be most susceptible, while larch and pine are less susceptible. Planting or favoring larch or pine in infected areas will result in less mortality in the future stands than would occur if Douglas-fir is replanted. Some mortality is still likely in larch and pine, but it should be less than in fir.

In stands primarily containing highly susceptible species such as Douglas-fir, Armillaria root rot will continue to spread from infected stumps and trees to adjacent healthy trees by root contacts and rhizomorphs. The only method of preventing spread in susceptible stands is to excavate stumps and large roots of infected trees. Stump extraction will also minimize infection of susceptible replacement stands. Cost estimates of $100-250 an acre including stump excavation, land clearing, grading, and planting have been reported for operations aimed at root disease control in severely infected pine-fir stands. Since severely infected stands in the survey area are few and located near existing roads, costs for disease control could be small. Much of the root disease control could be accomplished during logging without greatly adding to costs.

Summary

1. Approximately 1,300 acres of mixed-conifer forest on the Kettle Falls Ranger District were systematically surveyed for location, extent, and cause of tree mortality.

2. Seven percent of the stems representing 20 percent of the board-foot volume (17 percent of cubic volume) was killed over an estimated 20-year period.

3. Armillaria root rot killed 2 percent of the stems representing 2 percent of the board-foot volume (3 percent of cubic volume), dwarf mistletoe killed less than 1 percent of the stems representing 6 percent of the board-foot volume (5 percent of cubic volume), bark beetles killed less than 1 percent of the stems representing 5 percent of the board-foot

volume (3 percent of cubic volume), and unidentified agents killed 5 percent of the stems representing 7 percent of the board-foot volume (6 percent of cubic volume).

4. Mortality caused by dwarf mistletoe and bark beetles was more prevalent in larger timber while mortality caused by Armillaria root rot occurred equally throughout all diameter classes.

5. Most mortality caused by Armillaria occurred in Douglas-fir, western redcedar, and grand fir. Larch and ponderosa pine appeared to be more disease tolerant.

6. Recommendations for root disease control include planting or favoring less susceptible species in mixed stands and stump excavation in stands primarily containing susceptible species.

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Table 1--Stocking (stems/acre) of mortality by causal agent and tree species

Species	All Trees Stems/Acre	Live Trees	Dead Trees and Cause				
			Armillaria Root Rot	Dwarf Mistletoe	Bark Beetles	Unknown	Total
			percent				
Douglas-fir	651.2	88	4	0	<1	8	12
Western redcedar	814.4	99	<1	0	0	1	1
Grand fir	112.2	91	<1	0	1	8	9
Western larch	20.8	64	9	27	0	<1	36
Lodgepole pine	23.6	80	1	0	5	14	20
Ponderosa pine	0.7	100	0	0	0	0	0
estern emlock	37.6	81	0	0	0	19	19
Engelmann spruce	32.5	94	0	0	0	6	6
Subalpine fir	3.7	100	0	0	0	0	0
Total	1696.7	93	2	<1	<1	5	7

Table 2--Volume (board-feet and cubic-feet/acre) of mortality by causal agent and tree species

Species	All Trees Bd. Ft/Acre Cu. Ft/Acre	Live Trees	Dead Trees and Cause: Armillaria Root Rot	Dwarf Mistletoe	Bark Beetles	Unknown	Total
			percent				
Douglas-fir	4031.5	78	3	0	8	11	22
	1338.6	82	4	0	6	8	18
Western redcedar	1275.4	96	4	0	0	1	4
	497.8	95	3	0	0	2	5
Grand fir	188.2	86	14	0	0	0	14
	123.8	92	5	0	1	2	8
Western larch	1610.2	67	0	31	0	2	33
	378.4	67	0	32	0	1	33
Lodgepole pine	227.0	69	0	0	15	16	31
	140.5	68	3	0	12	17	32
Ponderosa pine	242.1	100	0	0	0	0	0
	46.7	100	0	0	0	0	0
Western hemlock	95.3	100	0	0	0	0	0
	30.4	100	0	0	0	0	0
Engelmann spruce	139.8	84	0	0	0	16	16
	51.9	90	0	0	0	10	10
Subalpine fir	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
Total	7809.5	80	2	6	5	7	20
	2608.1	83	3	5	3	6	17

Table 3--Stocking (stems/acre) of mortality
by causal agent and tree DBH class

DBH Class (in.)	All Trees Stems/Acre	Live Trees	Dead Trees and Cause				
			Armillaria Root Rot	Dwarf Mistletoe	Bark Beetles	Unknown	Total
			percent				
0.0-0.9	1019.6	98	1	0	0	1	2
1.0-1.9	135.3	80	3	0	0	17	20
2.0-2.9	146.2	85	2	0	0	13	15
3.0-3.9	100.4	84	2	0	0	14	16
4.0-4.9	102.3	96	2	0	0	2	4
5.0-6.9	81.0	86	6	1	2	5	14
7.0-8.9	44.1	88	<1	3	2	7	12
9.0-10.9	25.0	87	6	4	1	2	13
11.0-20.9	39.2	81	3	6	4	6	19
+	3.6	80	0	6	8	6	20
Total	1696.7	93	2	<1	<1	5	7

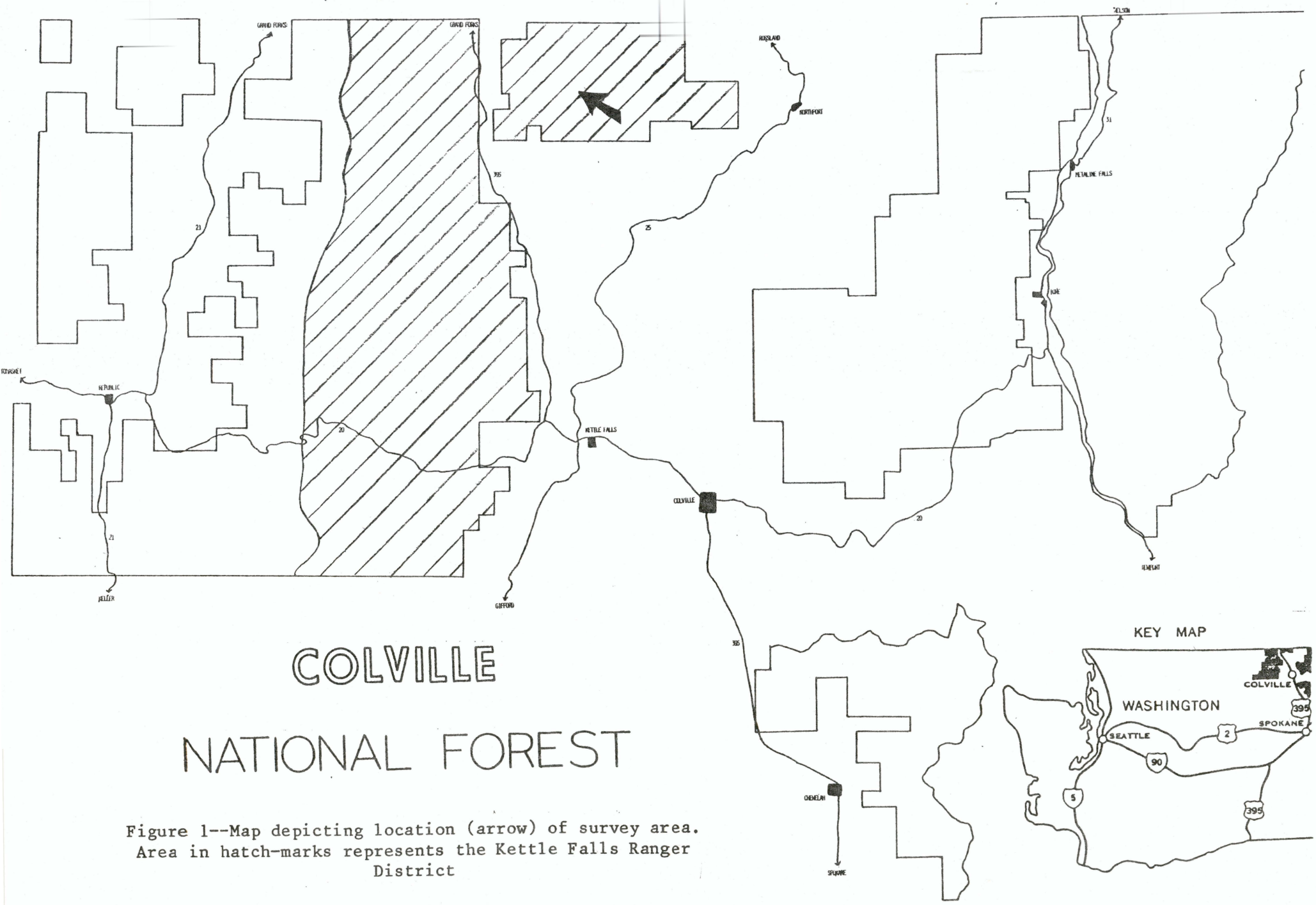

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Figure 1--Map depicting location (arrow) of survey area. Area in hatch-marks represents the Kettle Falls Ranger District

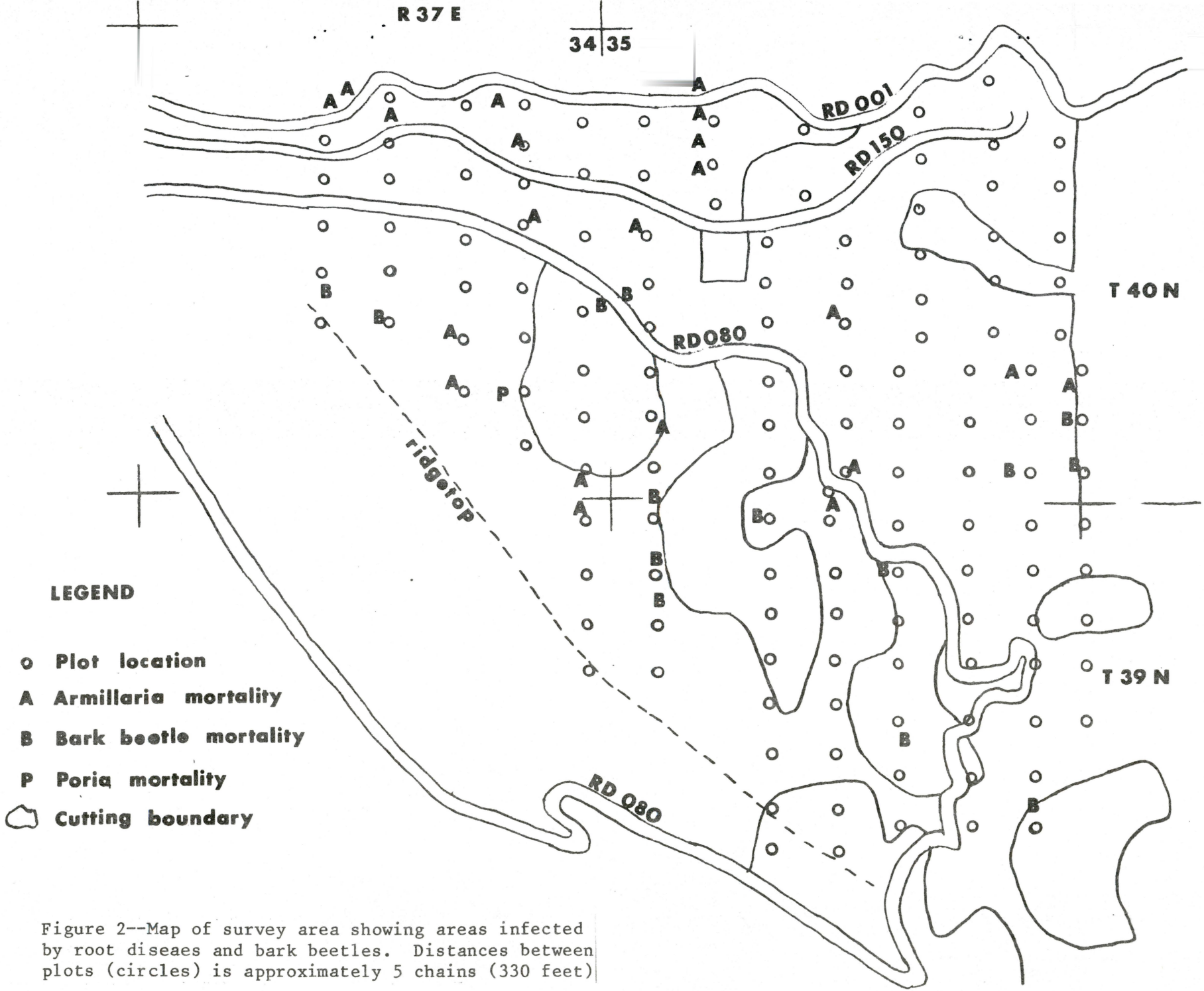

Figure 2--Map of survey area showing areas infected by root diseaes and bark beetles. Distances between plots (circles) is approximately 5 chains (330 feet)

Figure 3--White mycelial fans of *Armillaria mellea* beneath bark of an infected Douglas-fir

Figure 4--Mortality caused by Armillaria root rot in a mixed conifer stand. Mortality is highest in Douglas-fir and lowest in larch and ponderosa pine.